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26 April 1954

MEMORANDUM FOR: Chief, Technical Services Staff

SUBJECT : Request for Initiation of Contract Negotiations

1. Description of the Project

Development of an inexpensive, light, leaflet rocket that will be capable of distributing propaganda leaflets over a selected area target at ranges of 500 to 2,500 yards.

2. Purpose of the Project

The purpose of this project is to perform the necessary research and development leading to an accurate and reliable leaflet rocket. This work is to be conducted in three phases. The first phase will cost [redacted] and will cover the design and construction of preliminary model components such as motor tubes, nozzles, igniters, fuze, propellant and its geometry and include internal ballastic testing as well as a few field flight tests. The second phase will cost [redacted] and will consist of redesign, model construction, static and flight testing with the emphasis placed on bringing all components of the unit to an equal degree of development, so that the item will enter the final phase ready for extensive field tests. The third phase, costing [redacted] will include the final designing, manufacture of a large lot of prototypes, design of launcher, sight and firing system and final flight test program. 50X1 50X1 50X1

3. Recommended Contractor

The recommended contractor is [redacted]. This corporation is conducting the TSS leaflet bomb project. They have done extensive work on rocket propellants for the Army and have shown that this undertaking is feasible. 50X1 50X1

4. Support Requirements

There are no support requirements per se, needed with other Government agencies. However, this office has previously submitted the contractor's proposal to [redacted] Chief Rocket Branch, R&D Division, OCO, and obtained his concurrence as to the feasibility of the rocket. During the course of this program TSS/MD will maintain liaison with [redacted] and consult with him from time to time on the technical aspects of this project. 50X1 50X1

SECRET

50X1

5. Total Cost

The total cost for this work has been estimated to be [redacted] The attached proposal is considered by TSS/MD to be reasonable. 50X1

6. Project Engineer

The Project Engineer for this project is [redacted] Room 2422 Quarters Eye, Extension [redacted] 50X1 50X1

7. Security Information 50X1

The project will be conducted on an unclassified basis; Agency interest is Secret.

[redacted] 50X1

Chief
Mechanical Division, TSS

Attachment:
Attached to Memo to Logistics Office

TSS/MD/[redacted] 50X1

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SECRET

26 April 1954

MEMORANDUM FOR: Logistics Office

ATTENTION : Chief, Contract Branch, Procurement Division

SUBJECT : Request for Initiation of Research Order No. 13 Under the Task Type Agreement with [redacted] 50X1 50X1

REFERENCE : [redacted] Proposal and Supplements dated 22 April 1954 50X1

1. Your office is requested to initiate Research Order No. 13 under Task Type Contract RD-45-8A with [redacted] 50X1 50X1

2. The purpose of Research Order No. 13 is to develop a leaflet rocket in accordance with the three phases outlined in the attached proposal. Upon completion of the first and second phases respectively, TSS/MD wishes to reserve the right to review the progress made during each phase before authorizing [redacted] to proceed with subsequent phases of the project. The third phase calls for the fabrication of 500 rockets for test and evaluation purposes. At least 100 of these are to be delivered to TSS/MD. 50X1

3. It is the understanding of TSS/MD that informed al monthly progress reports and rates of expenditure are to be submitted to this office. Technical reports are to be submitted at the conclusion of the various phases and a final report with complete specifications and drawings at the end of the project. The final units as delivered to this office should include the rocket launching tube, sight firing system, range card, and be packaged so as to be protected against the elements (moisture vapor, dropping, handling in shipment, etc.) 50X1

4. The total cost of this task has been estimated at [redacted] over an eighteen month period. Charges for this project should be made against Allotment No. 4-2502-10.

5. This project will be conducted on a unclassified basis; Agency interest is Secret.

SECRET

6. Further technical information concerning this work may be obtained from [redacted] Room 2422 Quarters Eye, Extension [redacted] 50X1

50X1

[redacted] 50X1

Chief
Mechanical Division, TSS

Attachments:
[redacted] Proposal dtd 22 Apr 54 50X1
TSS/MD Requisition No. 3231-54

TSS/MD,[redacted] 50X1

APPROVED FOR OBLIGATION OF FUNDS:

____
Research Director

Distribution:
Orig & 1 - Addressee
1 - Comptroller
1 - Exec. Sec., Res. Bd.
1 - TSS/Budget
1 - TSS/SS
1 - TSS/LASO
1 - Project File
1 - [redacted] File 50X1
1 - MD Chrono

FORM NO. 36-125
DEC. 1951

Rocket Leaflet

REQUISITION FOR SUPPLIES

SECRET

54- 8469

[redacted] 50X1

Req'n. No. TSS/MD 3231-54

Date 26 April 1954

Page 1 of 1 Pages

Office [redacted] 50X1

Acct. Charge [redacted]-2502-10 | Project Chg. [redacted] 50X1

SOURCE OF SUPPLY: Purchase

DELIVER TO:

(Signature of Acct. Officer)

Acc't. No. 155-7-H

RECEIPT: I Certify that the quantities of items and/or [redacted] ved in serviceable condition except as otherwise indicated:

(Date)

[redacted] 50X1

5/6/54

ITEM NO.	STOCK NO.	NOMENCLATURE	QUANTITY	UNIT OF ISSUE	UNIT PRICE	AMOUNT
1		It is requested that [redacted] be advanced to				50X1
		[redacted] in accordance with				50X1
		Memorandum for: Logistics Office, Attn: Contract				
		Branch, Procurement Division, Subj: Request for	[redacted]			50X1
		Initiation of Research Order No. 13 under the				
		Task Type Agreement with [redacted]				50X1
		[redacted]				[redacted] 50X1

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX NOTHING FOLLOWS XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

50X1

Requests for status of this requisition should be referred to Procurement Division making reference to above P/A Number.

recd - released SCS 5/6 cvg 10 am

5/10

RETURN

SECRET

22 APR 1954

PROPOSAL FOR DEVELOPMENT OF A SPECIAL ROCKET TO DELIVER LEAFLETS

1.0 GENERAL

The problem of delivering leaflets from a remote location with air-burst distribution exists in cases where the planted mortar is not practical. A suitable vehicle would be a rocket or missile which would have the following characteristics:

A. Range up to 2000-2500 yards

B. Accuracy:

Azimuth	-	± 150 ft. at Range
Elevation	-	150 ft. ± 50 ft. at Burst
Range	-	± 150 ft.

C. Unit must be capable of being loaded in the field.

D. Packing case must be used as launcher. Set-up, training and firing to be accomplished without additional instrumentation.

E. In action, rocket shall have minimum noise and flash characteristics.

F. Payload shall be equivalent to present mortar.

G. At burst, rocket shall disintegrate, leaving a minimum number of pieces capable of inflicting injury in gravity fall. To ensure this, emphasis shall be placed on paper and cardboard as materials of construction. The entire unit shall be destroyed by the burst.

H. Rocket, complete with case shall have minimum weight and maximum portability.

I. Unit should be inexpensive; cost target is [redacted] per unit in lots of 20,000. 50X1

J. When packed in case, unit should be suitable for long storage, at widely varying temperatures and humidities.

Although these requirements present some unusual difficulties and pose problems peculiar to this vehicle, the following proposal indicates that the goal may be attained. The cost is estimated at [redacted] for a development program lasting eighteen months. 50X1

The program will result in the manufacture of at least 500 units of the selected design. 400 units will be test fired to prove the limits of performance of the rocket. 100 units will be delivered for tests by others. Test data and firing tables will be included in progress reports. In addition to reports, a complete set of drawings, specifications, and operating directions will be prepared as part of the project.

2.0 THE PROBLEM

The development of the required rocket will require the solution to several problems:

A) A propulsion system which will reliably deliver the vehicle to the desired point in space with uniform accuracy.

B) A fuze which will initiate the burster system at the point (A) regardless of the location of point (A) within the range of the rocket.

C) A burster which will disintegrate the rocket and will spread the leaflets over the required space without damaging them.

D) An initiating system which will give reliable ignition of the rocket motor and will, if required, interlock with the fuze.

E) A rocket body, nose, fuze body, and fins or jets which will withstand the rigors of handling, shipping, launching, and flight, but will shatter into a large number of small, inoffensive and harmless pieces.

F) A shipping case which will double as launcher. It should be light, easy to handle, simple to convert into a launcher, and readily destroyed after using.

In addition to solving the above problems, models must be built and tested to prove the solutions. At least 50 final tests under simulated field difficulties should be made to demonstrate the practical effectiveness of the operating unit.

3.0 PROPOSED SOLUTION

Preliminary studies indicate that the required vehicle can be designed and built in several ways. For the purpose of this proposal, specific choices have been made between possible designs and mechanisms. In the course of the development, these choices will be re-examined. As empirical data is collected, many modifications will be required of the theoretical design. However, at this point, the most desirable system looks like this:

A) Size (See Drawing) 5" Diameter 30" long

B) Weights:

All-Up, Ready to Fire	8.8 lbs.
Propellant (Max.)	1.7 lbs.
Payload	1.1 lbs.

C) Flight System:

Spin Stabilized at 68 RPS minimu.

Velocity: From 100 to 500 ft/sec in increments depending on the ranges selected.

(See further explanation in Section 4.0)

Burning Time: .14 seconds nominal

Time to Target:22 seconds - all ranges - nominal

Angle of Elevation: 45° for all ranges

D) Initiation: Electric Squib or fuze

E) Propellant: Modified M-7 double base

F) Burster: Black Powder or Double Base

G) Materials of Construction: See Drawing

H) Fuze: Single Delay Train

The above design was derived from consideration of all the requirements and incorporates certain novel features we believe to be peculiar to this unit.

Because the motor tube must operate at a high pressure, it was desirable to form the motor of several small tubes rather than a single tube of large diameter. This will permit cardboard or plastic, lined with asbestos paper to be used.

With a number of motor tubes, each with its own nozzle in use, the possibility of changing the range by changing the velocity became apparent. Appendix I and Chart I show the considerations affecting this system. Within the planned range, and the effective gas velocity, the relationship between all burnt velocity and mass ratio is practically linear, allowing this method of range control to be used. Although the actual velocities remain to be determined, the regularity of this system for 500, 1000, 1500, 2000, and 2500 yards is adequate to demonstrate the practicality of the method.

Spin stabilization is selected over fins because the accuracy from a static launcher is greater and the control of the unit is simplified.

By using variable velocity method of range control, the fuzing of the burst action is reduced to a single time delay element as the time to target is the same in all cases. Also all firing will be done at a single angle of elevation. By using the 45° angle it is felt that errors in the time delay will have a small effect on range at burst, due to the steep angle of descent. In a flatter trajectory, this error could easily be critical to the range accuracy. However, if in practice it develops that the time delay error gives excessively erratic elevation at burst, a smaller standard firing angle may be selected.

The above plan is only one method of solution. The unique features may boomerang in practice, but considering the requirements of the unit, it is believed that this is the best starting choice.

As an alternative, it is possible to sele ct a fixed all burnt velocity of 400 or 500 ft/sec., to vary to firing angle of elevation, and to cut a delay fuze to suit each case. This will give greater flexibility in service, but the rocket and the launcher will cost more to make, the possibilities of operational error will be increased, and the control of the unit will be more difficult. If desired, the two designs can be compared during the development.

4.0 WORK PROGRAM

To carry out the development, a responsible project engineer will be assigned who is familiar with the mechanical engineering and exterior ballistics required. Primary assistance will be given him by the laboratory where the interior ballistics, powder grain geometry, and propellant itself will be developed.

When the preliminary design is complete, static tests will be conducted on complete units to determine thrust, burning time, and general behavior of the motor, fuze, and burster. Design changes will be made until the unit passes all static test requirements.

Flight samples will then be prepared and tested for flight behavior. The method will probably be developed during the tests, but present plans are for simple performance tests to determine whether or not the rocket will deliver the leaflets as desired.

Field testing will undoubtedly result in further redesign, followed by more tests. This cycle is expected to be repeated twice before a final set of firing data can be collected.

Where possible, high speed pictures will be taken and data collected to verify the design. These will be submitted with reports.

The attached Development Schedule shows the planning as now conceived. The division of Engineering labor is considered to be:

1 Project Engineer full time 18 mo.	3,000 hrs.
1 Ballistician part time	500 hrs.
1 Chemist - Propellant & Burster	1,000 hrs.
1 Chemical Engineer part time	500 hrs.
1 Designer - Mechanical Eng. part time	1,000 hrs.

The personnel to be assigned to the project have considerable background and experience in Ballistics, Projectile Design, and Propellent systems. The fuze design is expected to derive from our previous pyrotechnic fuze systems for signals. It is not our policy to designate individuals for a project prior to undertaking the actual work, but we believe that this matter poses no problem at this time.

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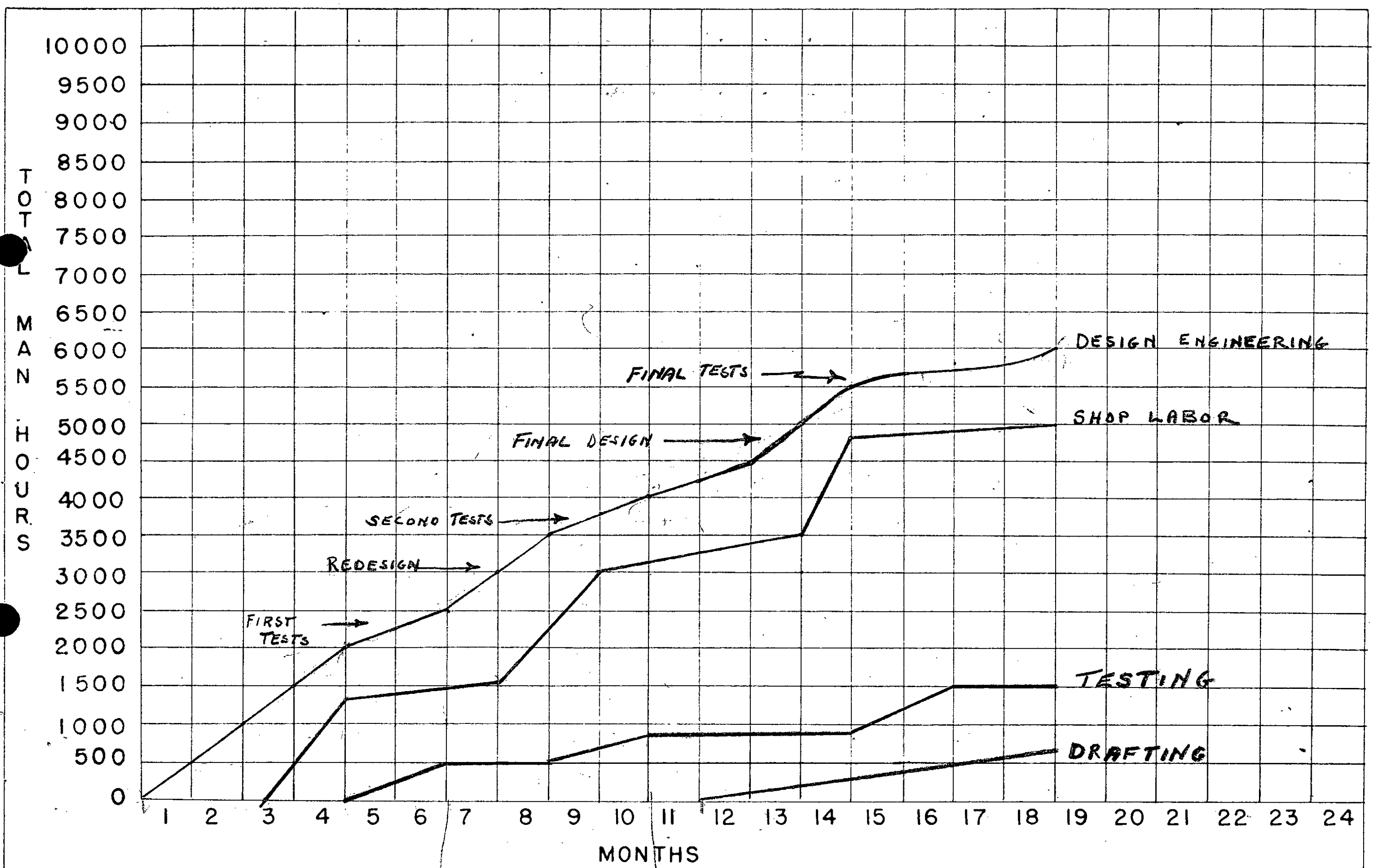

DEVELOPMENT SCHEDULE

LEAFLET ROCKET

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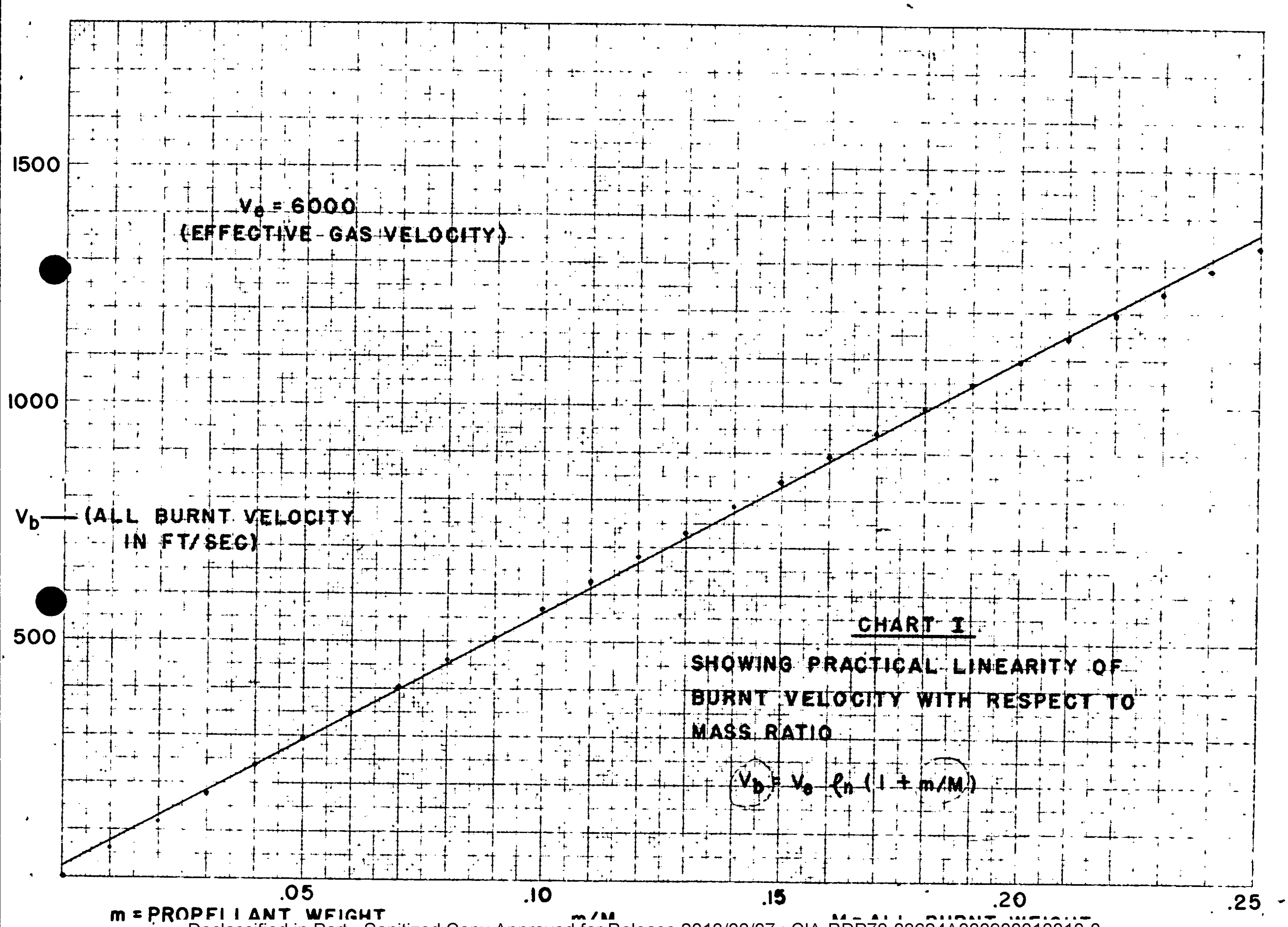
V_o	Max. Range at 45^o	Time to 500 Yds.			Time to 1000 Yds.			Time to 1500 Yds.			Time to 2000 Yds.			Time to 2500 Yds.		
		15^o	30^o	45^o	15^o	30^o	45^o	15^o	30^o	45^o	15^o	30^o	45^o	15^o	30^o	45^o
100	800		17.3	21.2												
200	1600	7.7	8.6	10.6		17.3	21.2			31.8						
300	2400	5.2	5.8	7.1	10.4	11.5	14.1	15.5	17.3	21.2		23.1	28.3			
400	3100	3.8	4.3	5.3	7.8	8.7	10.6	11.6	13.0	15.9	17.7	19.8	24.2		23.1	28.3
500	3850	3.1	3.5	4.2	6.2	6.9	8.5	9.3	10.4	12.7	13.8	15.4	18.9		18.0	22.0
600	4500	2.6	2.9	3.5	5.2	5.8	7.1	8.5	9.4	11.6	12.4	13.8	17.0	14.5	16.2	19.8
700	5200	2.2	2.5	3.0	4.4	4.9	6.1	7.2	8.0	9.8	10.4	11.5	14.1	12.1	13.5	16.5
800	5800	1.9	2.2	2.6	3.9	4.3	5.3	6.2	6.9	8.5	9.5	10.7	13.1	11.2	12.4	15.2
900	6400	1.7	1.9	2.4	3.4	3.8	4.7	5.5	6.1	7.5	8.3	9.2	11.3	9.7	10.8	13.2
1000	7050	1.6	1.7	2.1	3.3	3.6	4.5	5.2	5.8	7.1	7.8	8.7	10.6	9.1	10.1	12.4
[illegible]00	7650	1.4	1.6	1.9	3.0	3.3	4.0	4.7	5.2	6.4	6.9	7.7	9.4	8.1	9.0	11.0
1200	8200	1.3	1.4	1.8	2.7	3.0	3.7	4.2	4.7	5.8	6.2	6.9	8.5	7.2	8.1	9.9

PRELIMINARY TABLE OF FLIGHT TIMES
BASED ON FACTOR C = 2

$\frac{W}{2 \times d}$

APPENDIX I



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APPENDIX II

The following are only a few of the more significant calculations used in designing the subject rocket. Despite their textbook appearance, they are quoted here to point out the large volume of mathematical work required to achieve a complete unit.

The range of the rocket is specified. From ballistic tables the initial velocity required can be determined for a given type of projectile. The mass of the propellant required can be determined by the equation:

$$V_b = V_E \ln\left(1 + \frac{m}{M}\right)$$

where V_b is the "burnt" velocity of the rocket

V_E is the "effective gas velocity"

m is the mass of the propellant

M is the mass of the projectile without propellant

The effective gas velocity depends on the rocket chamber pressure, the nozzle expansion ratio and thermodynamic properties of the propellent gasses. In well designed rocket motors with commonly used solid fuels V_E is in the range 6000 - 8000 ft/sec. The geometry of the rocket must bee designed to provide the required mass of the propellent with sufficient surface area S. to maintain the equilibrium pressure in the rocket chamber with a given nozzle throat area A_T S may be calculated by

$$S = \frac{A_T \quad C_D \quad P_{eq}^{\,1-n}}{\rho^1 \quad c}$$

where C_D is the "discharge coefficient" of the propellant

Peq is the chamber pressure

$\rho^1 = \rho_s - \rho_q$ ρ_s is density of solid propellant

ρ_q is density of propellant gas

c and n are the burning rate constants of the propellant.

For the given equilibrium pressure the burning rate will be r, given by the burning rate law

$$r = c\rho^n$$

and the mass burning rate of the propellant M is

$$M_b = S\,p\,r$$

the burning time is given by $t_b = \frac{m}{M_b}$

Nozzle cant required for spin stability is

$$\tau = \arctan\left(\frac{4\,s\,K_M\,\rho_a\,d^3\,B}{M^2\,R^2}\right)$$

where s is stability factor required by projectile

ρ_a is density of air

d is diameter of rocket

R is radius from center of rocket to center of nozzles in ring

K_M is overturning moment of projectile

B is projectile's transverse moment of inertia

Spin attained is given by

$$N\ \text{rdn/sec} = \frac{M\,V_b\,R\,\tan\tau}{A}$$

where A is axial moment of inertia of projectile.

For ranges from 500 to 2500 yards the range is shown to be approximately linear with V_b and V_b is approximately linear with $\frac{m}{M}$. These conditions are sufficient for the feasibility of the incremental motor tube plan to obtain incremental ranges.

In the design of the rocket for this project, several sets of figures have been run off, including many of the calculations required which are not shown above. No single set of figures has been exact for the required unit, but the theoretical data "Brackets" the requirements so closely that FURTHER CALCULATIONS WILL NOT BE MADE UNTIL actual ranges are approved. The design shown is feasible, but the exact numbers will require many hours of further work, both on the board and in the field.

MODIFICATIONS - PROPOSAL FOR DEVELOPMENT OF A SPECIAL ROCKET TO DELIVER LEAFLETS

1.0 GENERAL

The following modification is intended to be a supplement to the proposed previously submitted. Therefore, the general design data are not repeated but merely referenced where appropriate. For clarity, certain material has been presented as revised; other modifications are made by reference only.

Certain valid points were raised after consideration of the original proposal. This information is presented to clarify these points.

2.0 THE QUESTIONS

From the discussions concerning the proposal, the following points were questioned:

2.1 Will the rocket performance be sensitive to temperature variation?

2.2 What can be done to compensate for such an effect?

2.3 Why was M-7 propellant selected?

2.4 What will be done if M-7 propellant is not suitable?

2.5 What effect will the multiple motor system have on the stability of the item?

2.6 How will uniform ignition of all motors be assured?

2.7 What exactly is the information given by the curve?

2.8 Does the preliminary range table mean that actual time to target will be 21.2 seconds as shown?

2.9 What spin rate will be critical for this item?

2.10 Can the work of the program be broken down into three phases so that funds can be committed as required?

3.0 DISCUSSION

The questions raised are valid and pertinent to the project proposed. However, it must be recognized that this proposal is intended to cover a development program, not the simple production of existing hardware. Therefore, the lack of exact information im the discussion of the questions reflects the experimental nature of the work. The required information depends to a large extent on the interaction of several complex variables, the resultant of which can only be determined experimentally.

3.1 Temperature Variation

The burning rate of the propellant will be effected by temperature. This is true of all propellants, the magnitude of the effect varying widely with the type of propellant and the range of temperatures. For certain ranges of temperature, certain propellants give substantially uniform performance, but these "mesas" are limited and the propellants are not suitable for all geometric configurations. Other propellants, possibly more suitable or more readily available, have burning rates which, although they are temperature dependent, do not vary sufficiently to be critical for the subject item.

The critical aspects of the proposed rocket are somewhat different from the normal criteria for a field weapon. Because of this difference, it is possible that temperature effects may not be significant.

One of the undecided questions concerns the temperature at which the item is expected to perform. For obvious reasons, the limits will be less critical than normal service specifications. At present, it is expected that $0^{o}F$ to $110^{o}F$ will cover the operating range. If this is a correct assumption, there is every reason to assume that M-7 or a similar propellant will be satisfactory.

Another aspect of variation due to temperature is the fact that, although the burning rate varies with temperature, the range varies much less. Exactly what the final effect on range and time to target will be for a given round must be determined empirically.

3.2 Compensation for Temperature Effects

If it is found that there is a distinct variation in performance due to temperature, there are four possible actions that can be taken.

3.2.1 If the variation is small, it can be "lived with". The target accuracy is plus or minus 150 ft. in range and 50 ft. in elevation at burst. Should the temperature variation fall within these limits, which is admittedly optimistic, it may be possible to ignore the problem.

3.2.2 A propellant with less temperature sensitivity, if necessary a "mesa" propellant, may be used instead of the proposed M-7.

3.2.3 If the variation with temperature is uniform and reliable, a firing table may be supplied providing a range correction. The correction can be applied by setting up the launcher at the distance from the target appropriate to the temperature.

3.2.4 If it is undesirable to allow the range to vary, correction canbe made by varying the elevation of the launcher. Previously, it has been assumed that the fixed 45 degree elevation of the launcher was desirable, particularly because of the simplified mechanism involved. However, a change of a few degrees will compensate for range variation with temperature if this is desired. With this arrangement, the 45 degree elevation would correspond to the lowest temperature on the temperature correction table, the elevation decreasing as the temperature rises.

The requirement for temperature compensation should be established before elaborate means are contrived to effect it. Two things are critical: (1) the performance of the round, and (2) the expected temperature variation.

3.3 Selection of M-7 Propellant

The preliminary selection of M-7 propellant was based on several convenient features. The personnel who will be involved in the subject project are familiar with solvent extrusion and have been handling M-7 recently. The propellant has a good burning rate at the low pressures required for lightweight motor tubes. However, this tentative choice should not be confused with a final design. In common with many design features of a new rocket, the propellant must be selected during the development and cannot be firmly designated beforehand.

3.4 Other Propellants

If M-7 proves unsatisfactory for the proposed item, several other propellants are available. Chief among these are the Navy double base propellants, JPN, N-4, and N-5. These are all temperature compensated to some degree and give better performance over a wide range than the present M-7. Because they are solventless, however, they have certain disadvantages. They require more processing equipment, their burning rates are lower at low pressures, and they are less susceptible to geometric versatility.

The personnel who are expected to be responsible for the subject project are familiar with the above propellants. Composite propellants are third choice. Although there are many successful composites, they are tailored generally to each individual application and it is felt that the funds required to develop a special propellant for this project are not justified at this point.

3.5 Multiple Motors and Stability

Apprehension was expressed that the removal of motor increments would shift the center of gravity of the missile and thereby cause radical changes in flight characteristics. Actually, the removal of motors will tend to shift the c.g. forward, improving the ballistic behavior of the rocket. The center of pressure, which depends on the external shape of the unit and its attitude will not vary.

Although both the burnt velocity and the speed of rotation will decrease with the reduction in thrust, it is assumed that the only negative effect on stability will come in the early stages of burning. This effect will be reduced to a minimum by the very short burning time.

Multiple motors are not entirely new, although the concept of incremental use of the motors is not recorded in the available literature. From the preliminary figures, it appears that the advantages of simple operation will outweigh any difficulties, but this cannot be assured without trial.

3.6 Uniform Ignition

Current multiple motor designs provide for nearly simultaneous ignition of the individual motors by one of two methods. Either a separate ignition is used for each motor or the "head ends of the motor tubes are connected in such a way that if some of the motors are ignited, the balance are ignited immediately afterward by the passage of hot gases over the burning surfaces, these gases being forced by the back pressure of the nozzles to flow through the unlighted adjacent motors. When all motors are ignited the pressure at all the nozzles is balanced by this head end connection.

For the proposed system, the use of multiple igniters is considered less desirable than the head end connection method.

3.7 Information derived from the Curve

The purpose of the curve is to show the linearity of the relationship between the burnt velocity and the mass ratio within the limits posed as practical for this development. This ratio is not linear for a wide range of burnt velocities and mass ratios. As can be seen even in the selected range the relationship only approximates linearity. The question answered by the curve is: "Will incremented values for burnt belocity result from selected incremental ranges of mass ratio?"

3.8 Preliminary Table

The table of flight times is only an example of the principle to be used to achieve uniform time to target for different velocities and different ranges.

It is recognized that this approach is unique and the preliminary table was included to demonstrate feasibility only. The actual velocities and ranges will vary somewhat from the arbitrary figures quoted, but to quote actual numbers would require extensive calculation.

However, the rapid and rough interpolation of the tabulated numbers will give an approximation of the expected figures

(1) Max range at 100 ft/sec is 800 yds. (from table)

(2) Range required is 500 yds, max from min. increment

(3) Probable velocity for 500 yds. 5/8 x 100 or 62.5 ft/sec.

(4) Velocities for other ranges will be direct multiples of the first figure, so:

500 yds.	62.5 ft/sec
1000 "	125.0 "
1500 "	187.5 "
2000 "	250.0 "
2500 "	312.5 "

If we check the figure in the existing table for max range at 300 ft/sec, we find that this is 2400 yds. The 312.5 ft/sec figure should be pretty close to actual design, therefore.

Time to target will be longer than that shown for any range, however. A rough check here indicates a time of the order of 30.+ seconds, because in each case the rocket will be operating at extreme range.

There are still many variables to be taken into account which will seriously displace the above estimate. The final numbers, in terms of velocity and time to target are not important at the moment. The important aspect is the relationship which will allow range fixing by the incremental method.

3.9 Spin Rates

Tests which have been made on spin indicate that of the improvement in stability to be gained by spin, by far the greatest improvement takes place in the first 800 rpm of spin rate. The difference, therefore, between a missile which spins at 800 + rpm and the same missile at 5000 rpm is much less than the difference between 800 rpm and no spin.

In terms of design this means that if the minimum spin is held above 800 rpm, there will be little difference in accuracy and stability even though the spin at higher increments is much greater.

3.10 Division into Phases

As requested, the work of the project has been divided into three phases. The separation is shown both on the Cost Sheet and the revised work schedule.

The division into phases has both advantages and disadvantages. The primary advantage is the smaller amount of money which is committed at any one time. The disadvantage is the tendency to lose continuity between phases. It is hoped this will be overcome by good planning and prompt action on the transition from one phase to the next.

Conceivably the work of any one phase may be incomplete at the end of the time and funds proposed. There may be a short inter-phase extension required to reach the required goal for this phase.

4.0 SUMMARY

After a review of the original proposal and the discussions previously referred to, there is no apparent reason to believe the difficulties foreseen cannot be overcome. However, it should be remembered that on any development of this kind, the answers are not entirely predictable.

Personnel can be made available to start the work as soon as an order is received. At present, no difficulties or delays are foreseen and the project is expected to move steadily once started.

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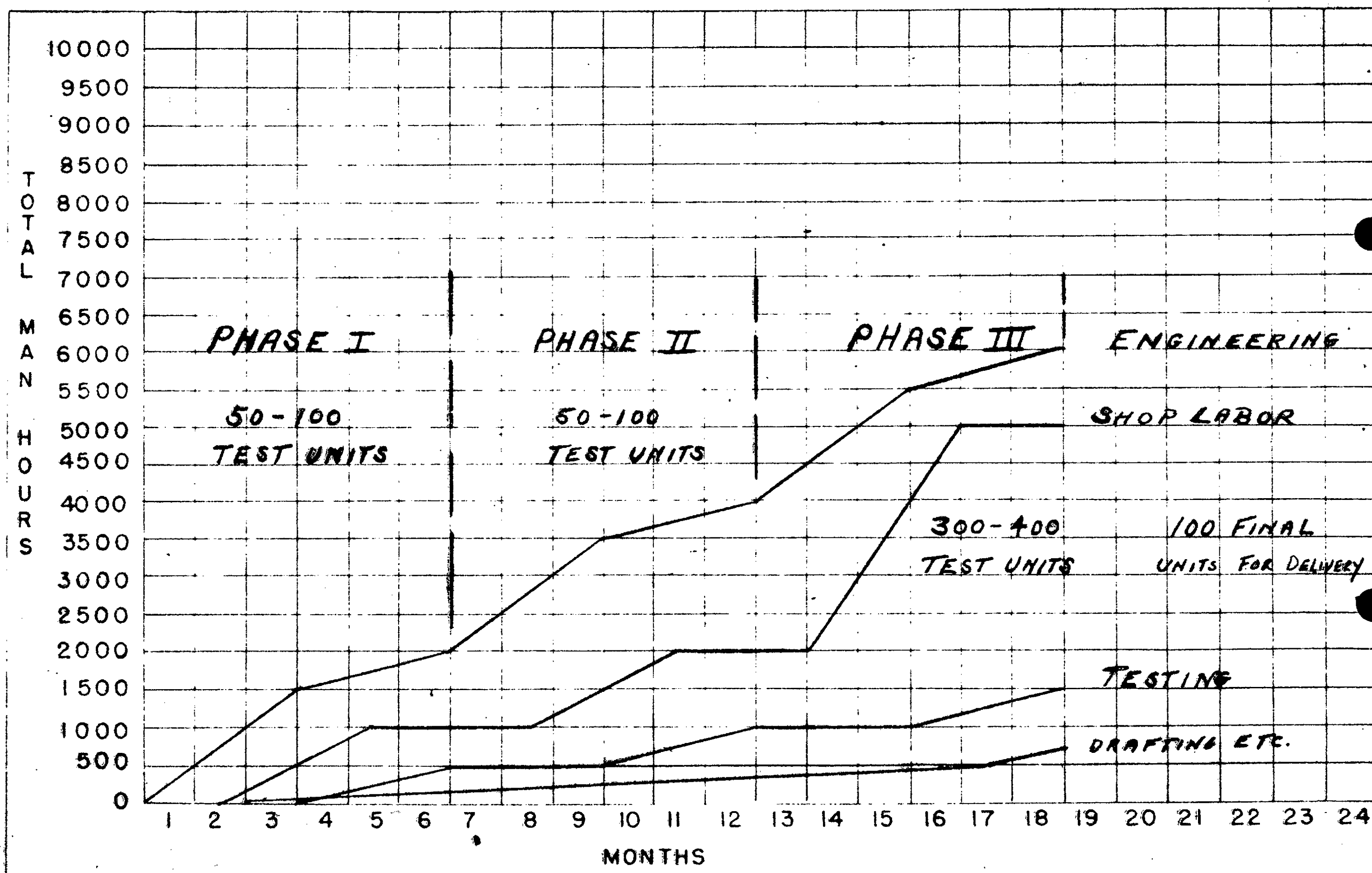

DEVELOPMENT SCHEDULE *LEAFLET ROCKET*

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The following is a record supplement to the recent proposal for the development of a leaflet rocket. This supplement covers the program for each of the phases shown in the schedule.

PHASE I FEASIBILITY STUDY

1. Complete mathematical analysis
2. Design and construction of preliminary models
    A. Materials and construction:
        Motor tubes
        Nozzles - shroud
        Igniters - body
        Fuze
        Bursting Charge
    B. Propellant
        Composition
        Geometry
3. Internal ballistic testing.
4. Field flight tests
5. Report

Attempt will be made to prove as far as possible in Phase I the feasibility of the item. Emphasis will be placed on the most difficult problems other than on refinement.

PHASE II INTERMEDIATE DEVELOPMENT

1. Redesign
2. Model construction
3. Static and flight testing
4. Report

Emphasis during this phase will be placed on bringing all components of the unit to an equal degree of development, so that the item will enter the final phase ready for extensive field tests.

PHASE III

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1. Final design
2. Manufacture of large lot of prototypes
3. Launcher and sight
4. Final flight test program
5. Preparation of final drawings, specifications, instructions, manual, firing tables, and packaging
6. Delivery of items
7. Final report on project

Phase III will concentrate on the production of a complete, useable round. Some compromise will have to be made between possible improvements and a serviceable unit which is not ideal in all respects, but every attempt will be made to perfect the item as far as possible.

Throughout the development, monthly progress reports will be submitted including fund reports. The report at the termination of each phase will be complete in as much detail as is practicable, reporting difficulties and failures behind the developmental changes.

As each phase draws to a conclusion, a final report and request for further funding will be submitted so that time is allowed for approval without delaying progress.

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